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SOME IMPORTANT DISEASES OF TOMATO IN NORTH CAROLINA

This bulletin is intended to give information about the common tomato diseases that will enable members of the Tomato Clubs in North Carolina to understand their nature, the measures that will prevent or reduce them, and the reasons for these control measures. Most of these diseases are caused by fungi. Fungi (singular, *fungus*) are plants, very simple in structure and of extremely minute size, so small that we know them by their effects rather than by direct observation of the plants themselves, unless a microscope is used that will magnify several hundred times. Fungi do not have the green substance (chlorophyll) that gives higher plants their characteristic color and enables these higher plants to manufacture starchy and sugary food out of the carbon dioxide (carbonic acid gas) and water. So fungi are forced to get such food substances already manufactured, and many attack the living tissues of crop plants or feed on dead plant remains for this purpose. Those that attack living plants are called parasites. They have distinct preferences for certain kinds of higher plants and for certain parts of a plant. Their growth and feeding usually lead to the death and decay of the part affected. There is a period of several days or even weeks between the first attack and the appearance of conspicuous effects. Many fungi, after killing the plant tissues, continue to live on the dead remains for a long time. In this way certain disease fungi can live over in the soil, sometimes persisting for several years.

Fungi have their special structures for reproduction and distribution. Usually they take the form of very minute, light, dustlike bodies known as spores. These may be produced in immense numbers on the surface of badly affected parts, carried freely and far by the wind, and germinate to produce new fungous plants when temperature and moisture are right and they happen to fall on the right kind of plant part.

In controlling plant diseases it is often, though not always, possible to coat the threatened part at the time when the spores of the fungus are likely to germinate with a chemical that will destroy the spores or the very young fungous growth that comes from them. Such chemicals are called fungicides. They must be used in such strength as not to injure the crop plant, and yet be able to kill the fungus. It is not possible to use them for destroying a fungous growth already inside the leaves or

other parts without at the same time seriously injuring these parts of the crop plant, thus doing more harm than good. Consequently, fungicides must be used just before the time of the expected attack in order to prevent the entrance of the fungus. Once inside, there is no hope from the use of fungicides, except possibly to check further spread to new points. Wet weather favors germination of fungous spores, and fungicides must be applied before rather than after such periods. The coating protects like armor and must be as complete as possible, because any unprotected spot may serve as an entrance place for the parasite. The coating will weather away in one to three weeks, and must be renewed often enough to have it effective during the whole danger period. This danger period will vary, for different fungi, with their peculiar habits, with the growth of the crop plant, and with weather conditions that may influence either crop or fungus. Because epidemics of crop diseases depend on so many things, we find them varying greatly in severity from season to season and in different localities.

Another important thing in crop disease control is to reduce as much as possible the number of spores or quantity of material that may cause infection. This means cleaning up and burning affected plant parts in so far as this may be practicable. This is a usual sanitary measure in the control of human or of stock diseases, as well as of crop diseases.

Every fungus has a technical or botanical name made up of two Latin words. These are given in parentheses in this bulletin, and are important when one wishes to refer accurately to the fungus. The disease caused by the fungus also has a name, frequently several names, as people have invented them without knowing the already established name. Common names of fungous diseases are often used carelessly, and mean little or nothing at all because of failure to note carefully the distinguishing features of different diseases.

If any one has difficulty in distinguishing tomato diseases in using this circular, *The Plant Pathologist, Agricultural Experiment Station, West Raleigh, N. C.*, will be glad to examine specimens and answer inquiries. He will be glad to give information about serious diseases of other crops as well.

Leaf Spot.—There are numerous brown spots on the leaves not much larger than a pin-head. Affected leaves turn yellow, curl and die. The lower leaves are attacked first. The disease may start in the seedbed, but usually is little noticed until the plants begin to bear, and is caused by a fungus (*Septoria lycopersici*) that reproduces itself abundantly throughout the whole growing season.

Control: Spray the plants with 4-4-50 Bordeaux mixture as soon as the disease first appears, which may be before the plants are set in the field. Repeat the application at intervals of two or three weeks for two to five times, depending on the danger from the disease. Use ammoni-

acal copper carbonate solution for late sprayings if sediment on fruit is undesirable. Destroy old plants at the end of the season.

Black Spot.—The spots are usually few on a leaflet and dark in color. They enlarge slowly, and may reach a size of half an inch in diameter. They often show faint target-board markings. The fruit is sometimes attacked, with the production of several to many slightly sunken, brown spots, slowly increasing to ¼ or ½ inch. Seldom very destructive. The fungus (*Macrosporium solani*) is the same as that causing the Early Blight of Irish potato foliage.

Control: Follow the spraying directions given under Leaf Spot. Destroy old plants.

Late Blight and Rot.—Spots on the leaves are brown, water-soaked, and enlarge rapidly. The whole plant may go down in two or three days and present the appearance of having been scalded with hot water. A whitish, downy growth may be seen on the lower surfaces in wet weather. On the fruit usually one or two large spots develop anywhere on the surface, but frequently at the stem end; these are water-soaked, and enlarge rather rapidly until one inch or more in diameter. As they grow old they may turn brown, but do not sink in or become soft for a long time. Succulent stems may be attacked. The development and spread of this disease is dependent on abundant moisture and a moderately cool night temperature. In North Carolina it does not give much trouble at altitudes of less than about 1,800 feet. In the mountains it is very destructive, but its occurrence depends on seasonal conditions, and epidemics do not occur every year. The time of its first appearance, and its continuance during the season, vary with conditions of moisture and temperature. The fungus (*Phytophthora infestans*) causing this disease is the same as that causing the very destructive Late Blight of Irish potato in more northern sections. In the mountains of North Carolina the Irish potato crops escape in large measure because they are generally matured when this disease prevails.

Control: Spray with 4-4-50 Bordeaux mixture as soon as careful observation shows the first indication of disease; or if unfamiliar with the disease, begin spraying before the earliest date when the disease may be expected in the locality. Repeat at intervals of one to three weeks for three to six times, as the severity of conditions may warrant.

Fusarium Wilt or Sleepy Disease.—This disease is caused by a fungus (*Fusarium lycopersici*) that lives over on decaying vegetable matter in the soil, and enters the roots of the young tomato plants either in the seedbed or after transplanting. The fungus grows slowly upward in the sap-tubes of roots and stems, interfering with the movement of water, and causing a wilting of the leaves about the time the plants begin to bear. The whole plant usually dies, but somewhat gradually; but occasionally, if infection is slight, there may be stunting of growth only. Some of the roots are dark and decayed. There is a brown discoloration

of the wood of roots and stems where the fungus grows in the sap-tubes. This disease is most extensively met in the more sandy soils of the eastern half of North Carolina. It is likely that it may be introduced into new places by means of spores of the fungus on the outside of the seed. Once in the soil, it may persist for three to five or more years.

Control: As a general precaution, soak tomato seed for ten minutes either in 1 to 1,000 corrosive sublimate (bichloride of mercury) solution, conveniently made from antiseptic tablets, or in formaldehyde solution, one tablespoonful in one gallon of water. Handle the corrosive sublimate with extreme caution; it is a deadly poison if taken internally. Plant in soil that is free from possibility of infection. Sometimes it is well to start plants in two or three lots of carefully selected soil, rejecting altogether any lot of plants showing any sign of disease. Be equally careful about the soil for transplanting. Do not set tomatoes in a spot where diseased tomatoes have grown. It is best in any case to practice a three- or four-year crop rotation. If wilted plants appear in the field, promptly pull them up and destroy them, roots and all. Do not let any diseased material reach the manure, since the fungus can grow well in such material, and be thus carried to new places. Clean up all refuse at the end of the season. Soil from an infected spot may be carried over the farm by surface water, on farm implements, on old stakes, or on the feet of stock or people.

Heavy applications of lime when the plants are set seem to have prevented the disease in infected soil in some cases. Resistant varieties of tomatoes are being bred at some of the Experiment Stations, but are too recent to be relied upon at present. Careful seed selection is advised where practicable.

Bacterial Wilt.—The symptoms are very much the same as for the Fusarium Wilt. The general wilting of the plant may progress more rapidly, and the internal discoloration of the stem may be more black than brown, and the inner bark may be involved as well as the wood. The most distinctive feature of this disease is that a dirty milky liquid can be squeezed out under pressure from the discolored areas of a cut stem. This is quite different from the clear watery sap, and contains millions of the bacteria (*Bacterium solanacearum*) which cause the trouble. The Fusarium fungus does not give any such appearance. The whole affected plant contains germs of disease that will be carried to the soil and so to other plants the same or the following season. Insects may transfer the disease by biting healthy plants after feeding on affected tissue. This bacterial wilt also attacks tobacco, Irish potatoes, eggplant, pepper and peanut, as well as Jimson weed, horse-nettle, and nightshade.

Control: Plan a rotation that will avoid growing susceptible plants in infected soil more frequently than once in four to six years. Pull up and destroy first infected plants, and clean up trash after a crop. Con-

trol insects. Avoid any transfer of infected soil. Chemical treatment of the soil has not proven effective for this disease.

Damping Off.—Seedling plants are affected. The stems become water-soaked at the surface of the ground, collapse, and fall over. Several soil-inhabiting fungi may cause this trouble. It is worst when seedlings are overcrowded in too moist soil with poor ventilation.

Control: Plant in uninfected soil. Avoid any excess in watering. Ventilate the seedbed well. Thin plants if too thick. Allow plenty of sunlight. Keep the surface soil stirred between the rows. If the disease appears in particular spots, remove plants and soil thoroughly from such places. If more general, sprinkle sulphur lightly over the ground, and cover with a fairly deep layer of clean sand that has been baked dry, applying when cool enough to handle comfortably.

Root Knot.—The general effect is a stunting of the growth of the plant, with a slow yellowing or misshapen growth of the leaves. The roots have numerous conspicuous swellings of varying size along their course which is an unmistakable sign of this disease. It is caused by worms called mematodes (*Heterodera radicicola*) of microscopic size that invade the roots and by their irritation induce the swellings. Root Knot occurs mainly in the sandy soils of the eastern part of the State.

Control: Do not plant in infected soil. Try to give slightly affected plants the most favorable conditions for general growth, and they may outgrow the trouble. Many broad-leaf crop plants are susceptible, and infested land should be planted in something like corn or small grain for several years.

Point Rot of Fruit.—The rot begins at the point or blossom end of the fruit. The spots enlarge rather rapidly until half or more of the tomato is involved. The area is brown, much sunken, and inclined to be somewhat dry. The cause of this trouble is not known with certainty. The common type seems not to be due to the attack of any fungus, and cannot be controlled by spraying. Deficiency in water supply during the growth of the fruits promotes this trouble. It is worst in the more sandy, drier types of soil, and in the hot, dry periods of the season. A sudden checking of water supply after a period of unusually rapid growth results in much of it, especially in overfertilized plants that have grown too luxuriantly. Exposure to intense sunlight probably increases this trouble independently of moisture deficiency. Sun scald is a different trouble.

Control: Try to secure even, normal growth of the plants and as equal as possible water supply. Artificial watering works wonders, but is not usually possible. Try to make the soil a storage reservoir for the rainfall by early, deep, and thorough preparation, by working in a considerable amount of decayed vegetable material, and by giving frequent cultivations to keep the surface well broken and dry as long as the growth of the tomatoes permits. Later, a covering of pine needles, straw, or old leaves about the plants will check evaporation of water during dry

periods. Plants that lie on the ground, from their shading effect, develop less point rot than staked plants, but staking may be advantageous for other reasons. Avoid any excess of nitrogen in fertilizing.

GENERAL CONTROL MEASURES.

Below are summarized the main control measures suggested above. Many of them will result in increased yields in any case; others will not be advantageous unless certain diseases are likely to occur. Remember that precautions to prevent crop diseases are a wise sort of crop insurance that pays in the long run. It is best to be on the safe side always.

1. **Plant uninfected seed.** As a general precaution soak the seed for ten minutes either in 1 to 1,000 corrosive sublimate (bichloride of mercury) solution, or in formaldehyde solution, one tablespoonful in one gallon of water.

2. **Plant in uninfected soil.** Try to get it where tomatoes and related crops have not previously grown. It may be well to plant in several lots of soil from different sources, finally using a batch of plants above suspicion. Soil for the seedbed may be fairly well sterilized before planting by drenching with boiling water. A more effective way is to drench with formaldehyde solution (1 pint of the 40 per cent formaldehyde in 12 gallons of water); but in this case the seed must not be planted for two weeks, and the soil stirred once or twice to allow the formaldehyde to evaporate.

3. **Give seedlings good conditions for growth.** If the seedling plants begin to rot at the surface of the ground, thin them, withhold water, give sunlight and ventilation. Sulphur and baked sand may be applied.

4. **Transplant to uninfected soil.** For early transplanting, the precautions under 2 may be observed. For field setting, tomatoes must be put where no diseased plants have been for at least three years. Plan a regular four- to six-year rotation that will put each tomato crop in a new place.

5. **Give the crop well-balanced fertilizing.** Especially avoid excess of nitrogen that may bring about failure of fruit formation, cracking at the stem end, or point rot at the blossom end.

6. **Preserve soil moisture.** Prepare the land early and deep, and add plenty of decayed vegetable humus. Cultivate lightly at frequent intervals as long as size of plants permits. Later cover the ground with a mulch of leaves or straw.

7. **Spray the Plants.** Use 4-4-50 Bordeaux, beginning when previous experience indicates that leaf diseases may be expected, or when close observation shows the very first indications. Inexperienced persons will play safe and make a first application before the plants are large enough to set out, a second just after they have become established in the field, and a third three weeks later. Others may be made at intervals of two

or three weeks during the growth of the plants. If sediment on the fruit is objectionable, use ammoniacal copper carbonate for late sprayings. Combine insect poisons with the spray material whenever needful.

8. **Destroy all hopelessly diseased plants.** Do this as promptly as they begin to appear. At the end of the season pull up all stalks. Do not let any infected material reach the manure. Prevent the transfer of infected soil by farm implements, old stakes, surface water, etc.

9. **Save seed** from plants that show marked resistance to disease, or try to secure strains that have been selected for resistance by reliable parties. Accept with caution advertising statements.

SPRAYING.

The amount of spray solution required to spray one-tenth acre of tomatoes will vary with the size of the plants and with the spraying apparatus used. Five to twenty gallons would be reasonable limits.

Any one of three or four types of spray pumps may be used, and may be procured through a dealer in seeds or farm implements. For use with copper-containing preparations the parts should be of brass. The lower priced galvanized iron outfits would be injured in time by the copper salts. Always rinse the pump thoroughly after using. A bucket pump can be used with an ordinary pail; it costs $2 or more. Portable compressed-air pumps are very handy, but are somewhat liable to get out of order; they cost $5 or more. Knapsack sprayers have a greater capacity, and are heavier to carry; they cost $8 or more. A simple type of tin hand sprayer with capacity of about a quart can be bought for 50 cents. It is possible to do effective work with this, but much time and exertion are required in its use, and one of the other types will prove a more profitable investment in the long run. Several persons can club together in buying and using a good pump that will be useful in many ways on any farm.

Select bright, dry days for spraying, and apply a thin, even coating, avoiding excessive dripping. Get a fine, misty spray that will settle on both sides of the leaves. A good nozzle and strong pressure are necessary for this.

BORDEAUX MIXTURE.

Bluestone (copper sulphate)----------	4 lbs.
Lime (best grade of unslaked or stone lime)----	4 lbs.
Water ----------	50 gals.

This formula is for 50 gallons of the 4-4-50 mixture. In making a smaller quantity, decrease all amounts in the required proportion. Dissolve the bluestone in 25 gallons of water. Slake the lime gradually to a thin, even paste, and add 25 gallons of water. Pour together into a third vessel these two dilute solutions of bluestone and of lime. Do not

pour one into the other, as the resulting mixture then will not be of the very best quality. Use the preparation within a few hours after mixing. The solutions of bluestone and of lime may be kept separately for weeks, but must be protected from evaporation, and accurate quantities used for mixing.

For control of leaf-eating insects, add arsenate of lead at the rate of 4 pounds of the paste or 2 pounds of the powder to 50 gallons of the Bordeaux mixture. Mix either form with a little water before adding.

AMMONIACAL COPPER CARBONATE.

Copper carbonate	5 ounces.
Ammonia (strong commercial, 26° B.) about	3 pints.
Water	50 gallons.

Make up the copper carbonate to a paste with a little water. Dilute the ammonia with eight times its volume. Add most of the dilute ammonia to the carbonate and shake until no more of the latter will be dissolved. Allow to settle, and pour off the solution; add part of the remaining ammonia to the residue of carbonate and shake thoroughly again. If necessary, use more ammonia. The whole object of this procedure is to use just enough ammonia to dissolve the carbonate, and no more. Three pints will be about right for ammonia testing 26° Baumé.

This is a clear fungicide, and is useful where the sediment deposited by Bordeaux mixture would be objectionable, as on fruit for select marketing. There is no danger of poisoning from using fruit sprayed with either mixture.

If arsenate of lead is used with this solution, lime should be added, 2 pounds to 50 gallons. In this case there would be a sediment, and no distinct advantage over using Bordeaux mixture.

Lime-sulphur preparations are less effective for tomato diseases than Bordeaux mixture or ammoniacal copper carbonate, but can be used to advantage.

For further information on this subject or in regard to plant diseases, address H. R. Fulton, Chief in Plant Diseases.

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